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Author Archie L. Gibson
Assistant Entomologist

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EXPERIMENTS WITH PENETRATING SPRAYS CONDUCTED IN WESTERN WHITE PINE 1940-41

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To: F. C. Craighead, in Charge, Forest Insect Investigations

From: James C. Evenden, in Charge, Coeur d'Alene Laboratory

Subject: Report "Experiments with Penetrating Sprays Conducted in Western White Pine 1940-41"

I am enclosing a copy of Mr. Gibson's report "Experiments with Penetrating Sprays Conducted in Western White Pine 1940-41". Copies have been sent to the Portland and Berkeley Laboratories and one has been routed through the eastern stations.

In connection with this report you will note that Mr. Gibson has again listed the results obtained from these experiments as a percentage of control. We are still arguing this question and hope to have a simpler and more significant method of determining results before further work is undertaken.

James C. Evenden

Enclosure

EXPERIMENTS WITH PENETRATING SPRAYS CONDUCTED IN WESTERN WHITE PINE 1940-41

INTRODUCTION

Tests conducted for a number of years in lodgepole pine and more recently in whitebark pine had indicated the effectiveness of penetrating sprays in controlling the mountain pine beetle. Practical application of the sprays in actual control gave excellent results against mountain pine beetle infestations in lodgepole pine on the Wasatch National Forest and at Grand Teton National Park. With the background of success in these two timber species, experimentation was shifted to western white pine, in which the same insect was causing serious losses to the more mature timber. At the outset of experimental work in western white pine, the problem of control with penetrating sprays seemed much more difficult due to thicker bark and different environment.

EXPERIMENTS CONDUCTED IN 1940

The initial tests of penetrating sprays in western white pine were limited to various ratios of fuel or Diesel oil to the naphthalene-orthodichlorobenzene mixture. These tests were planned with the expectation that the lower concentrations would prove too weak to give satisfactory control and thus indicate minimum effective strength. For each test seven logs 30 inches long were selected, with all conditions as to size of logs, brood abundance, stages of brood development and environmental conditions as near similar as possible. Six similar untreated logs furnished data on normal brood mortality and development. In table 1 are given the sprays used and the results obtained from them.

Table 1 - Data on effectiveness of penetrating sprays against brood of the mountain pine beetle in western white pine - Coeur d'Alene, Idaho - 1940

Exp. No.	Composition of spray Parts by volume of: Diesel oil	Chemical	Other ingredients	Living brood per sq. ft. in logs when: Treated	Date	Exam-ined	Date	Normal mortality as indicated by check logs: Number	Percent	Percent control due to treating	Sq.ft. of treated area examined	Cost per gallon
1	1½	1 Sat. sol. naph. in orthene at 50° F. (3 lb. per gal. 1/	None	67	5-9-40	.5	5-25-40	21	31.5	99	10.3	$0.36
2	3	1 Same solution as in Exp. 1	"	108	5-11-40	.4	5-29-40	39	36.5	99	10.1	.26
3	6	1 Same solution as in Exp. 1	"	105	5-13-40	.1	6-4-40	48	45	100	10.5	.19
4	9	1 Same solution as in Exp. 1	"	75	5-15-40	1.1 2/	6-4-40	32	43	97.5	10.0	.16½
5	9	1 Same solution as in Exp. 1	Santomerse D 1% by weight	72	5-15-40	1.8 2/	6-5-40	32	45	95.5	10.8	.21
6	9	1 Same solution as in Exp. 1	Santomerse D 2% by weight	130	5-20-40	2.3 2/	6-4-40	46	36.5	97	10.3	.25
Check logs				92	5-9-40	44.5	6-5-40	44.5	52		8.7	

1/ Saturated solution of naphthalene in orthodichlorobenzene at 50° F. (3 lb. per gal.).

2/ Brood conditions on last examination prior to general emergence from check logs. Subsequent examinations showed the following brood condition:

	Living brood per square foot on June 20	July 6-8
Exp. 4	.4	none
5	.6	.2
6	.1	.2

An inepection of table 1 reveals a high mortality of brood from all sprays tested. The higher survival per square foot indicated for experiments 4, 5 and 6 as of June 4 and 5 is not a true index of effectiveness, survivors having still further decreased by June 20 and July 8 to even less than in experiments 1, 2, and 3, as may be seen in note 2 under table 1. Lethal action of the weaker solutions had been merely slower than the more concentrated mixtures used in experiments 1, 2, and 3, and in the meantime had retarded development of survivors sufficiently to prevent any emergence. Data from examinations of treated material subsequent to June 5 were not included in the body of table 1 because general emergence in check logs had begun shortly after that time and any subsequent comparisons of brood differences in treated and check material would have been of little value. Individual log data are not shown in table 1 because of the uniform mortality obtained in all sprayed material.

The writer is of the opinion higher temperatures prevailing where the experiments were conducted at Coeur d'Alene, than are common in white pine sites at that time of the year, were responsible for the rapid control obtained from the sprays. In experiment 1, 100 percent mortality was found in some logs in less than 12 days. As the ratio of naphthalene-orthodichlorobenzene solution to oil decreased, the period between treatment and effective control lengthened, but as brood development in treated material was retarded sufficiently to prevent emergence, the increase in period was immaterial.

The costs of the sprays used in experiments 1 to 4 are based on $0.10 per gallon for Diesel oil and $0.70 per gallon for orthodichlorobenzene, and were as shown in table 1. Wetting agents increased the costs of sprays used in experiments 5 and 6. The spray used in experiment 4 was found to be the cheapest of those tested.

CONCLUSIONS

Results from these experiments were so much better than expected that the writer was of the belief either higher temperatures or some unrecognized factor, peculiar to the place where the experiments were conducted and not present on western white pine sites, was responsible for the rapidity of action of all sprays and for the excellent control shown in experiments 4, 5, and 6. It hardly seemed possible that the higher temperatures alone could be responsible for the increased effectiveness. For the above reason the writer was reluctant on the basis of these tests to recommend the method for use in western white pine, and wished to duplicate some of the tests in 1941 as well as try other sprays.

TESTS CONDUCTED IN 1941

During the winter of 1941 it was decided by the Washington office of the Forest Insect Division and the Forest Service to conduct a control project on Steamboat Creek of the Coeur d'Alene National Forest, using the penetrating spray that had proved so effective on the Wasatch National Forest project. A report of the Coeur d'Alene project has been submitted 1/. In the following pages are given the results of the practical tests conducted by treating crews on this project, as well as the experiments by the writer. The latter were conducted in three different places on the control area and covered a wide variety of site, host, and brood development conditions. Adequately infested short logs of western white pine were again used with a duplication of conditions that would occur in actual control except that the logs were shaded sufficiently to prevent solar killing. The tests conducted are listed in tables 2 and 3.

1/ Station report "Experimental Bark Beetle Control Project, Coeur d'Alene National Forest, Spring 1941", by James C. Evenden.

Table 2 - Sprays tested against brood of the mountain pine beetle in western white pine in 1941 - Steamboat Creek, Coeur d'Alene National Forest

Experiment number	Composition of spray: Parts of Diesel oil	Composition of spray: Lethal material	Oil-base Sprays: Date in 1941 of Treatment	Date in 1941 of Examination	Number of logs treated	Average percent of mortality	Cost per gallon 1/
		Sat.sol.of naph. 2/ in orthene 3/ at 50° F. (3 lb. per gal.		6-18	1		
				7-2	1		
1	10	1 part	6/6	7-23	2	100	$0.16
			5-20	7-18	4	99	
				(6-17	1		
2	8	Same as in 1	6-4	(7-23	3	99	.17
			5-20	7-18	4		
3	6	" " " "	6-6	7-23	4	100	.19
4	4	" " " "	5-20	7-17	4	100	.23
5	2	" " " "	5-20	7-18	4	100	.32
		Orthodichlorobenzene					
6	10	1 part	6-12	7-22	4	93 4/	.15½
			5-22	7-18	4	100	
				(6-18	1		
				(7-2	1		
7	8	Same as in 6	6-4	(7-23	2	99	.16½
8	7	" " " "	5-22	7-17	4	100	.17½
			5-22	7-18	4	100	
				(7-2	1		
9	6	" " " "	6-4	(7-23	3	99	.18½
10	5	" " " "	5-22	7-17	4	96	.20
11	4 5/	" " " "	6-6	7-23	4	99	.22

Table 2 (continued)

Water-base Sprays

Experiment number	Composition of spray: Quarts of water	Quarts of orthene	Emulsifier	Date in 1941 of: Treatment	Examination	Number of logs treated	Average percent of mortality	Cost per gallon
12	3	1	4 oz. oleic acid 1½ oz. triethanolamine	6-12	7-22	4	97½	$0.33
13	4	1	Same as in 12	6-11	7-22	3	100	.27
14	5½	1	" " " "	6-12	7-22	4	58 6/	.20½
15	4	1	50 cc. Triton #720	5-20 6-4	7-17 (7-2 (7-23	3 (1 (2	95½ 99	.23
16	4	1	100 cc. Triton #720	6-12	7-23	4	92	.29
17	4	1	200 cc. Triton #720	6-12	7-22	4	80	.40½

1/ Based on costs as follows:

Diesel oil	$0.10 per gallon
or orthodichlorobenzene	$0.70 per gallon
naphthalene (flakes)	.08 per pound
oleic acid	2.00 per gallon
triethanolamine	.35 per pound
Triton #720	.51 per pound
water	no cost

2/ Naphthalene (flake form)

3/ Orthodichlorobenzene

4/ Incomplete mortality believed to be largely due to lighter spraying.

5/ Logs sprayed with water, to simulate rain, prior to treatment.

6/ Coverage with spray not as heavy as with oil-base spray possibly responsible for much of survival.

Table 3 - Sprays tested by treating crews against brood of the mountain pine beetle in western white pine in 1941 - Steamboat Creek, Coeur d'Alene National Forest

Experiment	Composition of spray	Date in 1941 of Treatment	Date in 1941 of Examination	Number of trees treated	Average percent of mortality
Same as 6 in table 2	Diesel oil - 10 parts Orthene - 1 part	6-11	7-29	3	87
Same as 7 in table 2	Diesel oil - 8 parts Orthene - 1 part	6-10 & 11	7-29 & 30	2 1/	100
Same as 8 in table 2	Diesel oil - 6 parts Orthene - 1 part	5-21	7-29	5 2/	95

1/ Two additional trees similarly treated not included because of evidence of poor spraying.

2/ Three additional trees similarly treated not included because of evidence of poor spraying.

Oil-base Sprays

Inspection of the data presented in table 2 reveals little difference in effectiveness of the two series (exp. 1-5 and 6-11) of dilutions of oil-base sprays tested. The slightly less control shown by the sprays limited to orthodichlorobenzene as the lethal ingredient can not be considered significant, as in some cases the logs were more lightly treated than those containing naphthalene as well as orthodichlorobenzene.

In table 3 insufficient control with the 10 parts oil, 1 part orthodichlorobenzene mixture applied by a treating crew may or may not have been due to borderline effectiveness of the spray. While there were no visual indications that thorough spraying had not been obtained, other treating by this crew had not been thorough and the trees used in this experiment may also have been perfunctorily treated. The writer is of the belief that further tests of 10 to 1 and weaker solutions should be made with not only the series containing oil and orthodichlorobenzene but also with similar dilutions containing naphthalene. This desire for further tests with sprays containing naphthalene is based on experience in lodgepole pine in 1938, in which it was found that the latter sprays were more effective than those containing merely the orthodichlorobenzene.

Water-base Sprays

The water-base sprays or emulsions yielded decidedly encouraging results in spite of some variability in mortality obtained. Sprays used in experiments 12 and 13 gave excellent results, but the more dilute mixture used in experiment 14 was possibly too weak. Results in experiment 15 averaged very good, but survival in one tree of those treated on May 20 was sufficiently high to throw some doubt on the expectancy of securing uniform control. The same conclusion can be drawn with reference to results from experiments 16 and 17. It seems possible that the low concentration of lethal material in the sprays used is on the borderline of effectiveness which under favorable conditions would be high but is low where such factors as wet, thick or green bark retard or prevent penetration of the lethal material in sufficient quantity to give uniform control.

The prospect of reducing costs of treating by the use of water-base sprays makes it advisable to thoroughly analyze their possibilities. While material costs per gallon are in excess of those for oil-base sprays found effective in control projects, the cost of transportation may make the price delivered at the point of use considerably less than the oil-base sprays. It can be readily seen that an 80 percent or greater reduction in the amount of spray material which must be taken into the field and the smaller amount of equipment needed may more than offset the additional cost of ingredients in water-base sprays. However, accessibility of

water and the necessity of mixing the spray in the field at the point of use are items of labor cost which must be considered in the final evaluation of water-base sprays. The writer believes tests with the latter should be duplicated in 1942 and that additional experiments with naphthalene added to the orthodichlorobenzene should be conducted to determine if it may increase effectiveness sufficiently to give consistent results. At present the writer feels reluctant to recommend any water-base sprays for control because of the variability in mortality observed during the past season.

Sprays on Wet Logs

The effectiveness of certain penetrating sprays in destroying brood of the mountain pine beetle under dry bark had been clearly demonstrated, but it was felt that rain would probably retard or prevent absorption of oil-base sprays, thus making them more or less ineffective. Experiments conducted in lodgepole pine had shown green or sour-sap bark reduced the control by the sprays, so it was naturally expected a similar reduction in effectiveness would occur when frequent and heavy rains fell during the work on the Coeur d'Alene project in the spring of 1941. Finally it became necessary to treat logs while still wet from recent rains and during light rains and showers, in order to complete the project. Because it was not known what the results of treatment under such conditions would be, an experiment was conducted in which four logs were first thoroughly sprayed with water immediately prior to treating with the oil-base spray. The spray selected was the same as that used on the project. When examined some time later the treatment was found to have caused complete mortality in three of the logs and 95 percent in the remaining one. Apparently, in western white pine, rain on the surface of a log does not prevent satisfactory control being obtained with an oil-base spray of the strength used on the control project.

Reducing Quantity of Spray per Unit of Bark Surface

An experiment was also conducted in which trees in a number of experiments were sprayed until the surface was merely completely covered and not saturated. The objective of this test was to determine if reduced quantities of the costly spray per unit of bark area would still give effective control. The logs tested were only sprayed until the surface was dark from the oil. Standard practice is to spray until the oil glistens on the surface and is ready to flow from it. The data secured from ten logs so treated were so variable as to preclude an accurate estimate of difference due to the type of spraying. On some logs the control secured was complete; on others apparently similar and treated in the same manner the mortality would be quite variable, from little or none on part of the log to complete on adjoining areas. The general statement can be made, however, that spraying in this manner does not give consistent results. Present indications are that the standard

practice of applying the spray until the bark surface glistens from the accumulated liquid and is ready to flow must be strictly adhered to.

CONCLUSIONS AND RECOMMENDATIONS

Results of the past two seasons' experiments in mountain-pine-beetle-infested western white pine and previously in lodgepole pine indicate oil-base penetrating sprays not only give excellent control but present concentrations can be reduced and still give effective results. The satisfactory results with concentrations of ten parts Diesel oil to one part orthodichlorobenzene, in which naphthalene at the rate of 3 pounds per gallon has been dissolved, indicate such a low concentration would give satisfactory control, but an additional test is desired before recommending it. Without the naphthalene a concentration of 8 parts Diesel oil to 1 part orthodichlorobenzene gave equally good results, but again further tests are considered desirable. Additional experiments with 10 to 1 and weaker solutions of oil and orthodichlorobenzene may show that they equal the two formulae just discussed in effectiveness, and are planned for the 1942 season.

Water-base sprays gave sufficient control to indicate they might be as effective as oil-base sprays, but further tests and a thorough analysis of the economic phases of their use are necessary before recommendations can be made.

An experiment this past summer, in which logs were sprayed with water prior to treatment with oil-base spray, gave results showing no significant difference in excellence of control from dry logs treated with the same spray. The results of this experiment show that as long as infested material is thoroughly treated, wetting from showers or light rains seems to have no effect on the mortality. However, results from weaker solutions under similar conditions may not give effective control.

SUMMARY

Tests with penetrating sprays made during the 1940 and 1941 seasons against brood of the mountain pine beetle infesting western white pine indicate excellent results can be obtained with various sprays. Although oil-base sprays containing naphthalene dissolved in orthodichlorobenzene gave an indicated higher mortality, the results can not be considered significantly different from those sprays containing only orthodichlorobenzene as the lethal agent. High mortality of mountain pine beetle brood with as dilute sprays as 10 parts Diesel oil to 1 part of a solution of naphthalene dissolved in orthodichlorobenzene and 8 parts Diesel oil to 1 part orthodichlorobenzene shows that the present 4 oil to 1 orthodichlorobenzene mixture is unnecessarily strong.

Water-base sprays gave excellent average results in four of six experiments, but showed sufficient variation in mortality to demand further testing before drawing definite conclusions.

Infested felled trees can be successfully treated with a spray of 4 parts of Diesel oil to 1 part orthodichlorobenzene after and during light rains where the bark surface has not become too wet.

Tests of light applications of spray failed to show that this economy can be practiced and acceptable control secured. Present standard practice of treating until the bark surface glistens and the liquid is ready to flow must be adhered to if satisfactory results are to be expected.

Further tests of oil-base sprays containing low concentrations of lethal ingredients are suggested as well as further experimentation with water-base sprays.